



EVQ4436-R-01A

45V, 6A, Low I_Q, Synchronous, Step-Down Converter Evaluation Board

DESCRIPTION

The EVQ4436-R-01A is an evaluation board designed to demonstrate the capabilities of the MPQ4436-AEC1, MPQ4436, and MP4436.

The MPQ4436 is a configurable-frequency, synchronous, step-down switching regulator with integrated internal high-side and low-side power MOSFETs. It provides up to 6A of highly efficient output, with current mode control for fast loop response.

The wide 3.3V to 45V input range accommodates a variety of step-down applications in an automotive input environment. A 1.7μA shutdown mode quiescent current allows the part to be used in battery-powered applications.

High power conversion efficiency across a wide load range is achieved by scaling down the switching frequency under light-load conditions to reduce the switching and gate driver losses.

Frequency foldback prevents inductor current runaway during start-up. Thermal shutdown provides reliable, fault-tolerant operation.

High duty cycle and low-dropout mode are provided for automotive cold crank conditions.

ELECTRICAL SPECIFICATIONS

Parameter	Symbol	Value	Units
Input voltage	V _{EMI}	3.3 to 45	V
Output voltage	V _{OUT}	3.3	V
Output current	I _{OUT}	6	A

FEATURES

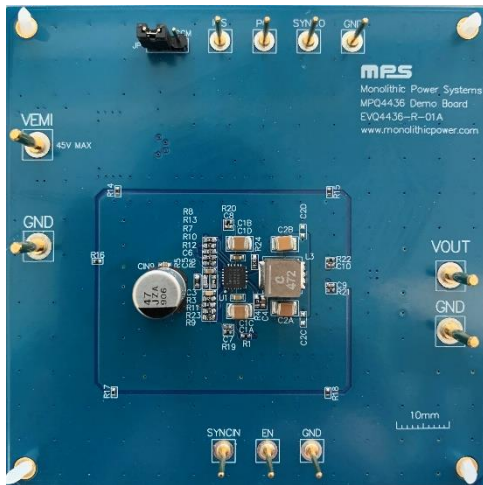
- Wide 3.3V to 45V Operating Voltage Range
- 6A Continuous Output Current
- 1.7μA Low Shutdown Supply Current
- 18μA Sleep Mode Quiescent Current
- Internal 48mΩ High-Side and 20mΩ Low-Side MOSFETs
- 350kHz to 530kHz Configurable Switching Frequency for Car Battery Applications
- Synchronize to External Clock
- Multi-Phase Capability
- Out-of-Phase Synchronized Clock Output
- Symmetric V_{IN} for Low EMI
- Power Good Output
- External Soft Start
- 100ns Minimum On Time
- Selectable Advanced Asynchronous Mode (AAM) or Forced Continuous Conduction Mode (FCCM)
- Low-Dropout Mode
- Hiccup Over-Current Protection
- Available in a QFN-20 (4mmx4mm) Wettable Flank Package
- Available in AEC-Q100 Grade 1

APPLICATIONS

- Infotainment
- Clusters
- Advanced Driver Assistance Systems
- Industrial Power Systems

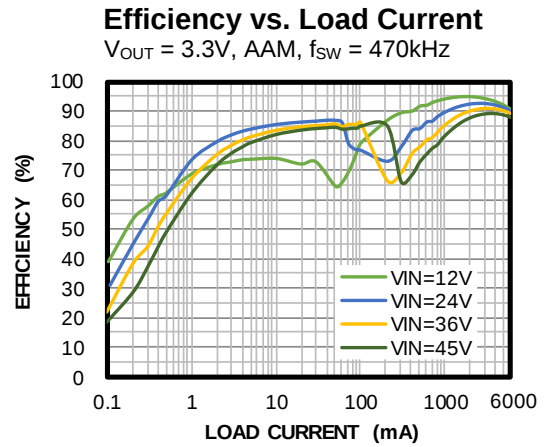
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EVQ4436-R-01A EVALUATION BOARD



(LxWxH) 9cmx9cmx1.3cm

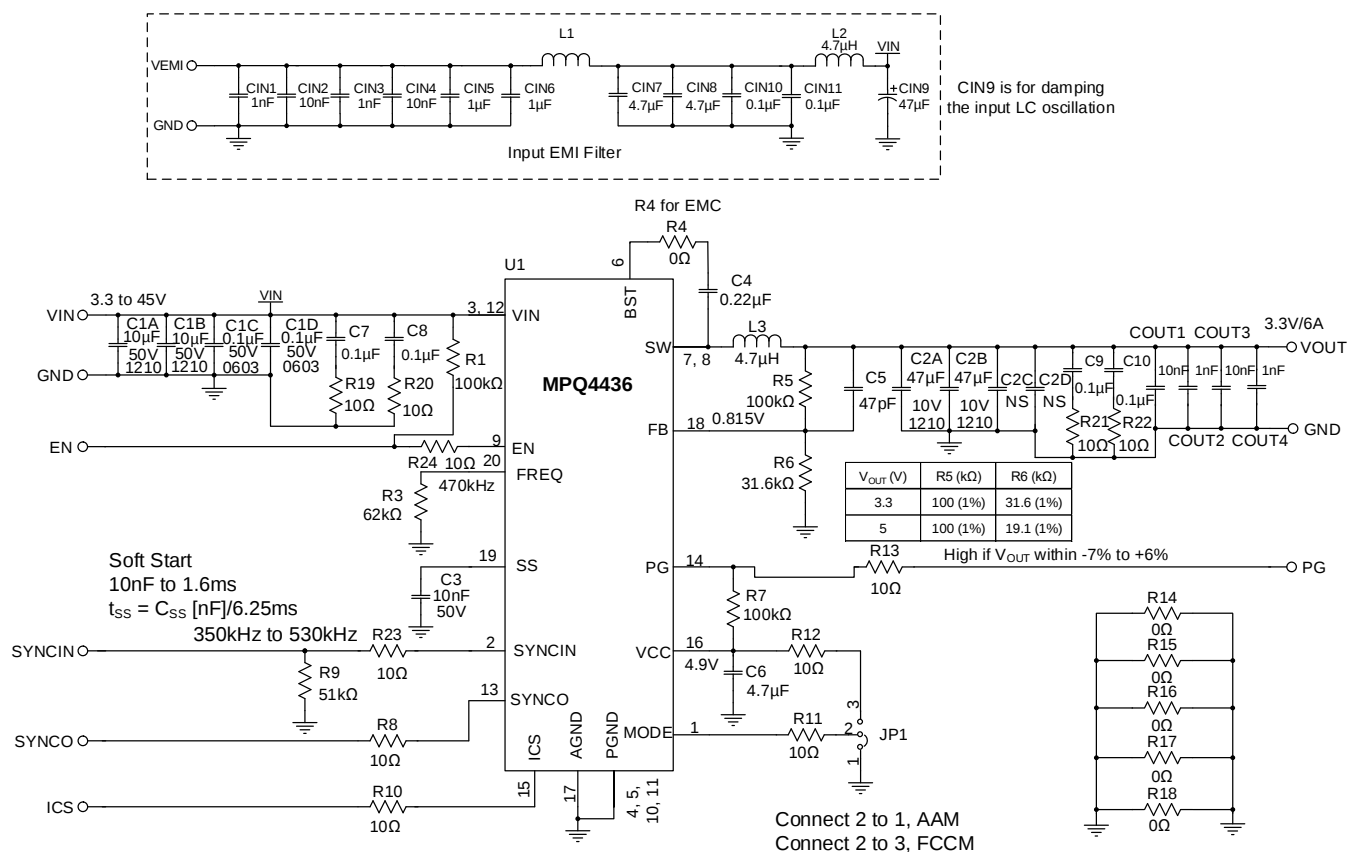
Board Number	MPS IC Number
EVQ4436-R-01A	MPQ4436GR-AEC1



QUICK START GUIDE

1. Connect the load to:
 - a. Positive (+): VOUT
 - b. Negative (-): GND
2. Set the load current between 0A and 6A. Electronic loads represent a negative impedance to the regulator. If they are set to an exceedingly high current, they can trigger over-current or short-current protection.
3. Preset the power supply output between 3.3V and 45V, then turn it off. If longer cables are used between the source and the board (>0.5m total), install a damping capacitor at the input terminals. This is highly recommended when $V_{EMI} \geq 24V$.
3. Connect the power supply output to:
 - a. Positive (+): VEMI
 - b. Negative (-): GND
4. Turn the power supply on. The board should automatically start up. The default V_{OUT} is 3.3V.
5. To use the enable function, apply a digital input to the EN pin. Drive EN above 1V to turn the regulator on; drive EN below 0.85V to turn the regulator off.
6. To use the sync function, apply a 350kHz to 530kHz external clock to the SYNCIN pin to synchronize the internal clock's rising edge.
7. JP1 selects forced continuous conduction mode (FCCM) or advanced asynchronous mode (AAM). Connect pin 2 (MODE) to pin 3 (VCC) of JP1 to force the MPQ4436 into FCCM. Connect pin 1 (GND) to pin 2 (MODE) of JP1 to force the MPQ4436 into AAM.

EVALUATION BOARD SCHEMATIC



Package Reference

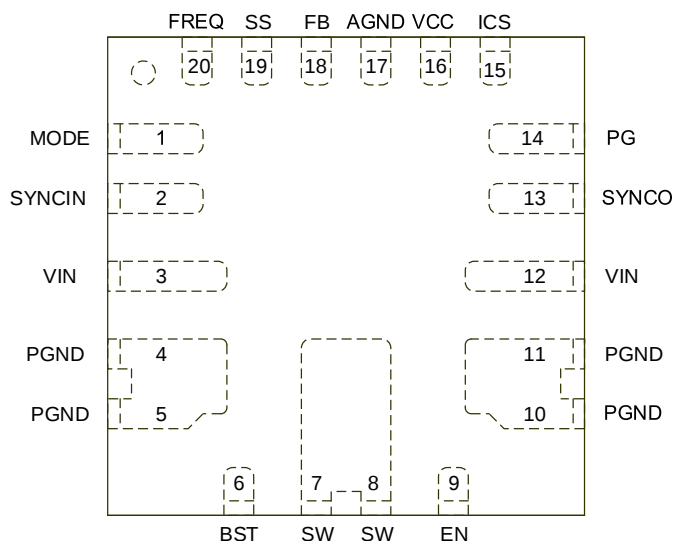


Figure 1: Evaluation Board Schematic

EVQ4436-R-01A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer P/N
4	CIN1, CIN3, COUT2, COUT4	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM216R71H102KA01
5	CIN2, CIN4, C3, COUT1, COUT3	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103KA01D
2	CIN5, CIN6	1μF	Ceramic capacitor, 50V, X7R	0805	Murata	GRM21BR71H105KA12L
2	CIN7, CIN8	10μF	Ceramic capacitor, 50V, X5R	1206	Murata	GRM31CR61H106KA12L
1	CIN9	47μF	Aluminum capacitor, 63V	SMD	Panasonic	EEE-1JA470UP
2	C1A, C1B	10μF	Ceramic capacitor, 50V, X7R	1210	Murata	GRM32ER71H106KA12L
4	CIN10, CIN11, C1C, C1D	0.1μF	Ceramic capacitor, 50V, X7R	0603	Murata	GCJ188R71H104KA12D
2	C2A, C2B	47μF	Ceramic capacitor, 10V, X5R	1210	Murata	GRM32ER61A476KE20L
1	C4	0.22μF	Ceramic capacitor, 16V, X7R	0603	Murata	GRM188R71C122KA01D
1	C5	47pF	Ceramic capacitor, 50V, COG	0603	TDK	C1608C0G1H470J
1	C6	4.7μF	Ceramic capacitor, 10V, X5R	0603	Murata	GRM188R61A475KE15D
4	C7, C8, C9, C10	0.1μF	Ceramic capacitor, 50V, X7R	0402	Murata	GRM155R71H104KE14D
2	C2C, C2D	NS				
1	L1		Magnetic bead, 6A	1806	Murata	BLM41PG600SN1L
1	L2	4.7μH	Inductor, 4.7μH, 31.5m, 6A	SMD	Cyntec	VCMT063T-4R7MN5T
1	L3	4.7μH	Inductor, 4.7μH, 14.4m, 11A	SMD	Coilcraft	XAL6060-472ME
1	R1	100kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-07100KL
1	R3	62kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-062KL
5	R14, R15, R16, R17, R18	0Ω	Film resistor, 1%	0402	Yageo	RC0402FR-070RL
1	R4	0Ω	Film resistor, 5%	0603	Yageo	RC0603JR-070RL
1	R5	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R6	31.6kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0731K6L
1	R7	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R9	51kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0751KL

EVQ4436-R-01A BILL OF MATERIALS (continued)

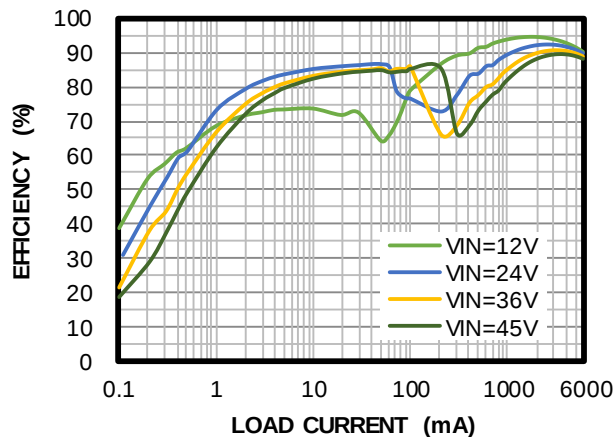
Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer P/N
4	R19, R20, R21, R22	10Ω	Film resistor, 5%	0402	Yageo	RC0402FR-0710RL
7	R8, R10, R11, R12, R13, R23, R24	10Ω	Film resistor, 1%	0603	Yageo	RC0603FR-0710RL
1	U1	MPQ4436	Step-down converter	QFN-20 (4mmx4mm)	MPS	MPQ4436GR-AEC1
1	JP1		Connector, 2x20, 2.54mm, right angle		Any	
5	VIN, VEMI, GND, VOUT, GND	Test point	2.0 golden pin		Custom	
8	SS, SYNCIN, FB, ICS, PG, SYNCO, EN, GND	Test point	1.0 golden pin		Custom	

EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. $V_{IN} = 12V$, $V_{OUT} = 3.3V$, $L = 4.7\mu H$, $f_{SW} = 470kHz$, $T_A = 25^\circ C$, unless otherwise noted.

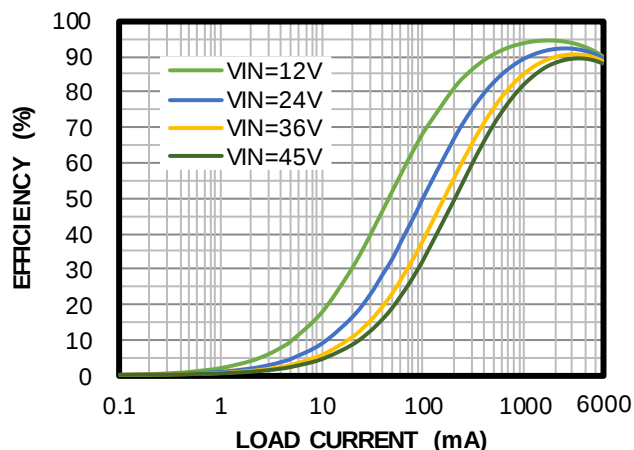
Efficiency vs. Load Current

AAM



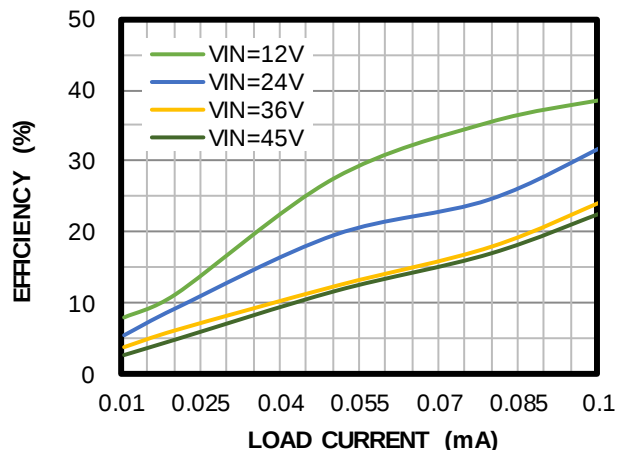
Efficiency vs. Load Current

CCM



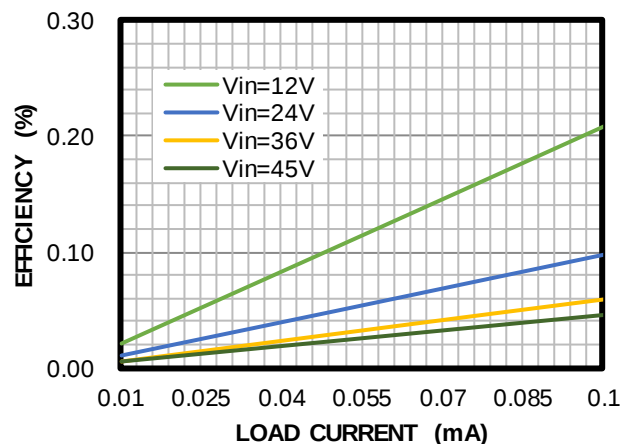
Efficiency vs. Load Current

AAM, extreme light-load conditions



Efficiency vs. Load Current

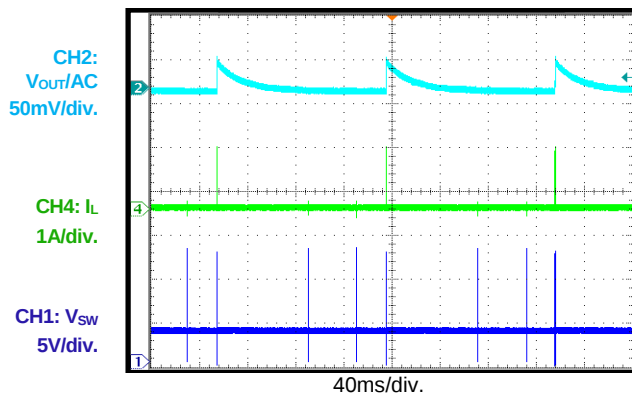
CCM, extreme light-load conditions



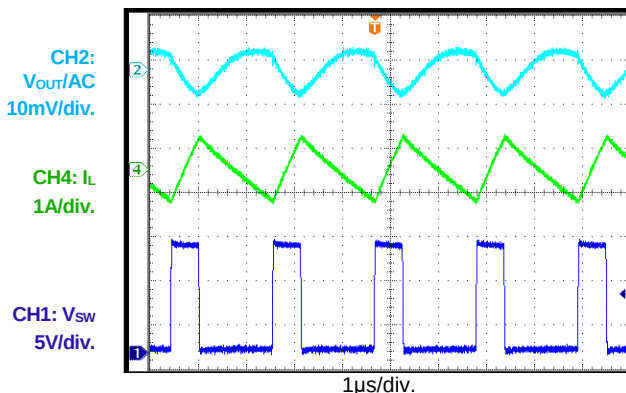
EVB TEST RESULTS (continued)

Performance curves and waveforms are tested on the evaluation board. $V_{IN} = 12V$, $V_{OUT} = 3.3V$, $L = 4.7\mu H$, $f_{SW} = 470kHz$, AAM, $T_A = 25^\circ C$, unless otherwise noted.

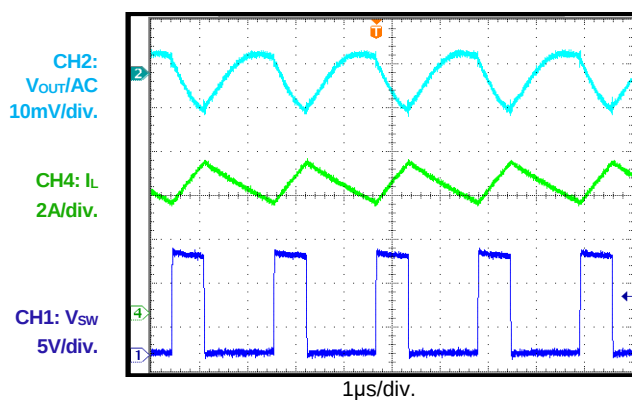
Steady State

 $I_{OUT} = 0A$, AAM


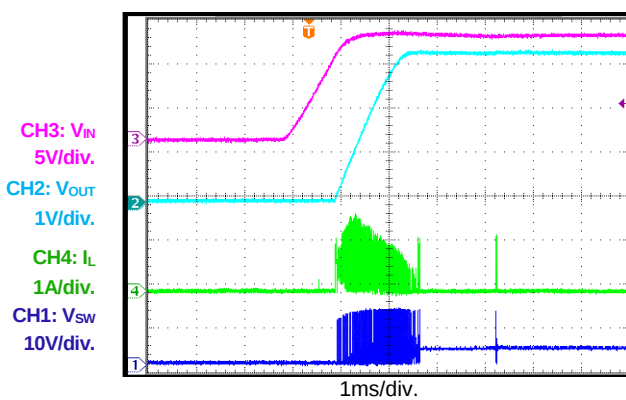
Steady State

 $I_{OUT} = 0A$, FCCM


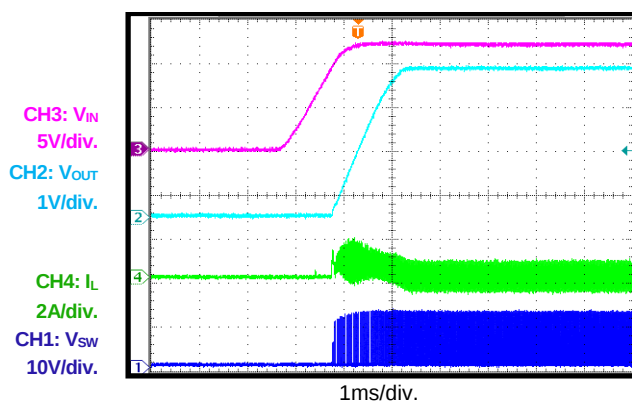
Steady State

 $I_{OUT} = 6A$


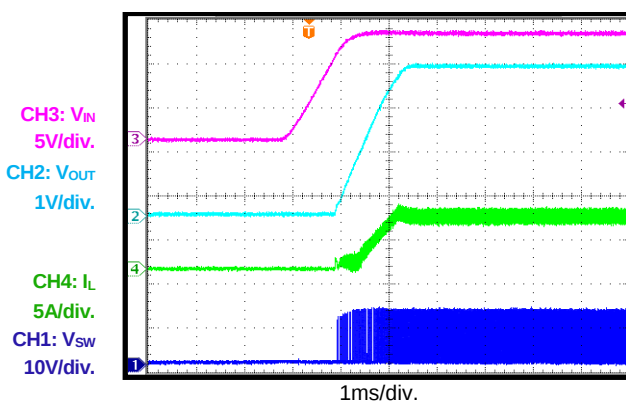
Start-Up through VIN

 $I_{OUT} = 0A$, AAM


Start-Up through VIN

 $I_{OUT} = 0A$, FCCM


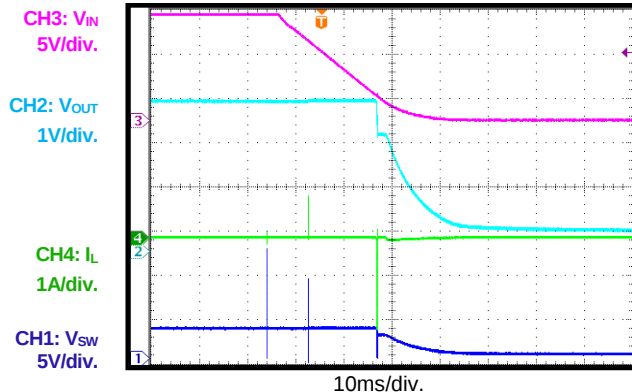
Start-Up through VIN

 $I_{OUT} = 6A$


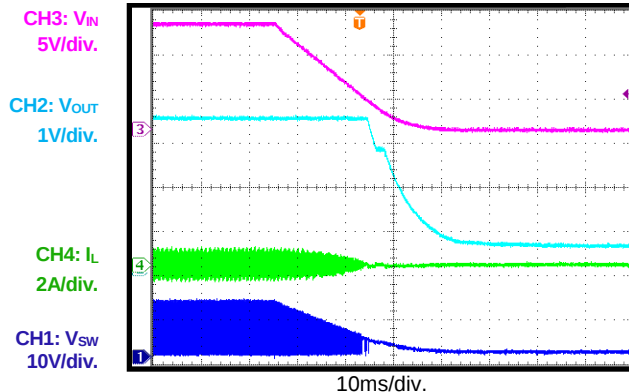
EVB TEST RESULTS (continued)

Performance curves and waveforms are tested on the evaluation board. $V_{IN} = 12V$, $V_{OUT} = 3.3V$, $L = 4.7\mu H$, $f_{SW} = 470kHz$, AAM, $T_A = 25^{\circ}C$, unless otherwise noted.

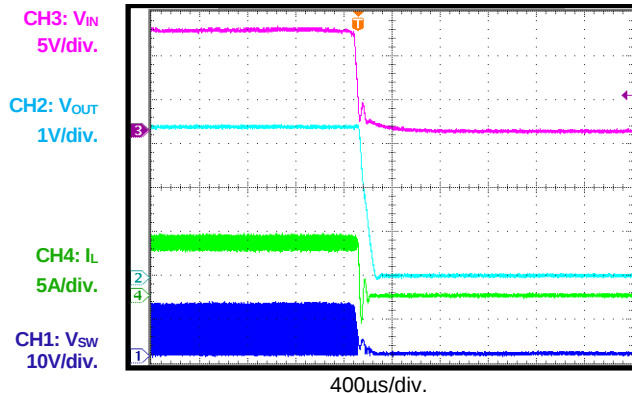
Shutdown through VIN

 $I_{OUT} = 0A$, AAM


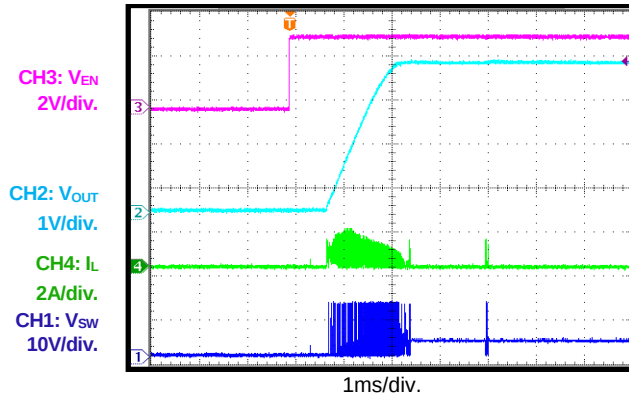
Shutdown through VIN

 $I_{OUT} = 0A$, FCCM


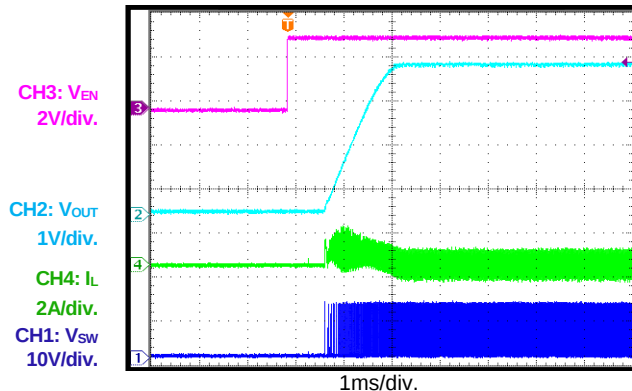
Shutdown through VIN

 $I_{OUT} = 6A$


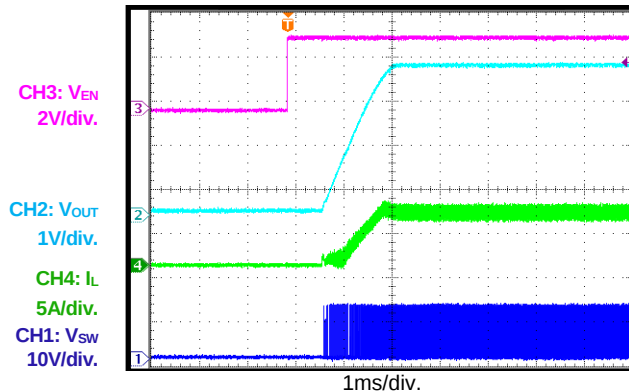
Start-Up through EN

 $I_{OUT} = 0A$, AAM


Start-Up through EN

 $I_{OUT} = 0A$, FCCM


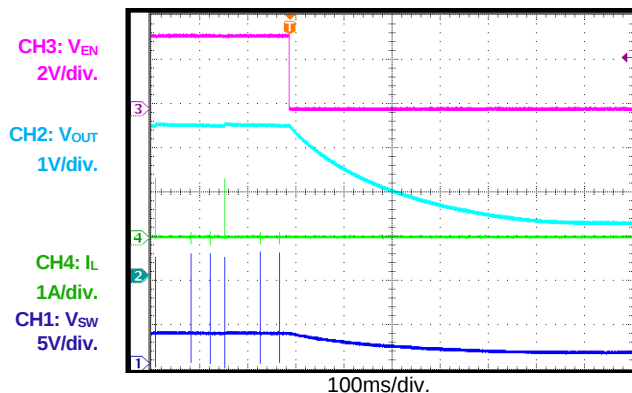
Start-Up through EN

 $I_{OUT} = 6A$


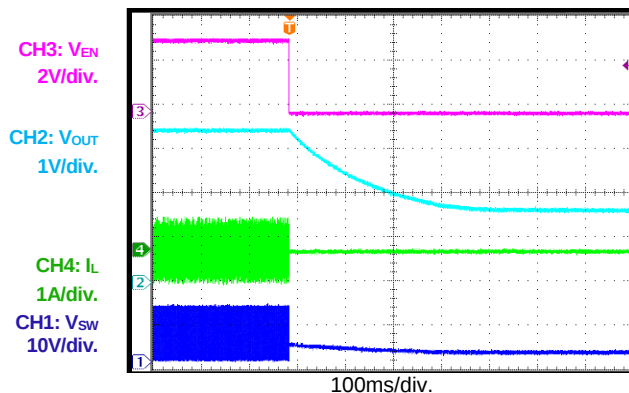
EVB TEST RESULTS (continued)

Performance curves and waveforms are tested on the evaluation board. $V_{IN} = 12V$, $V_{OUT} = 3.3V$, $L = 4.7\mu H$, $f_{SW} = 470kHz$, AAM, $T_A = 25^\circ C$, unless otherwise noted.

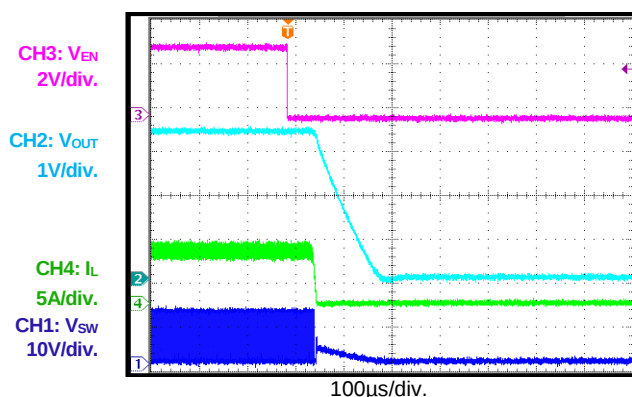
Shutdown through EN

 $I_{OUT} = 0A$, AAM


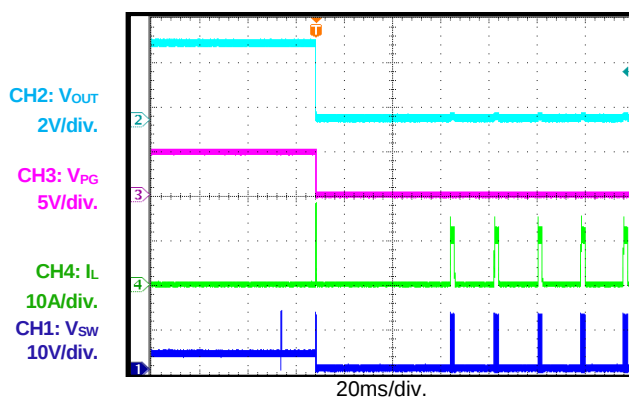
Shutdown through EN

 $I_{OUT} = 0A$, FCCM


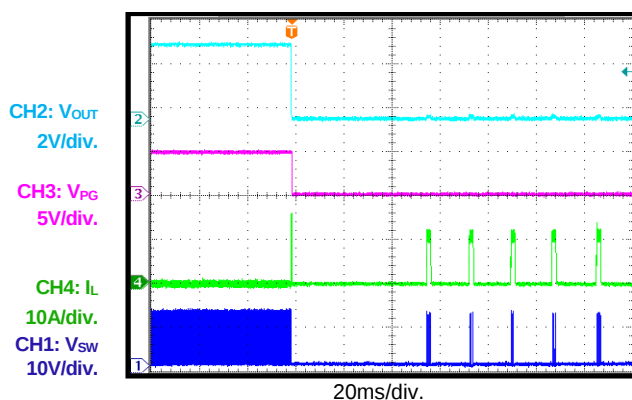
Shutdown through EN

 $I_{OUT} = 6A$


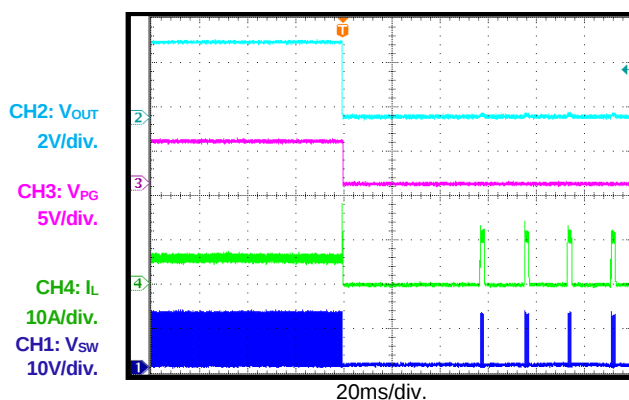
SCP Entry

 $I_{OUT} = 0A$, AAM


SCP Entry

 $I_{OUT} = 0A$, FCCM


SCP Entry

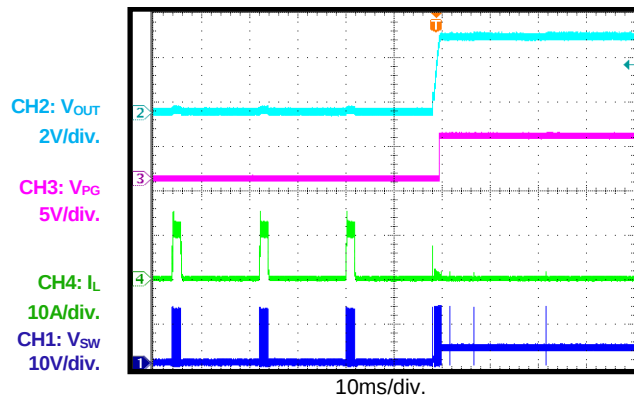
 $I_{OUT} = 6A$


EVB TEST RESULTS (continued)

Performance curves and waveforms are tested on the evaluation board. $V_{IN} = 12V$, $V_{OUT} = 3.3V$, $L = 4.7\mu H$, $f_{SW} = 470kHz$, AAM, $T_A = 25^\circ C$, unless otherwise noted.

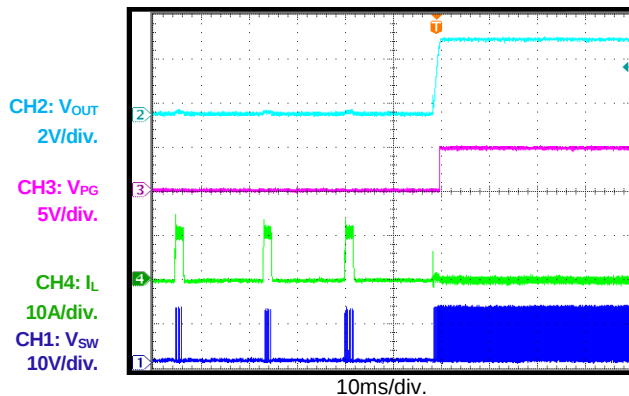
SCP Recovery

$I_{OUT} = 0A$, AAM



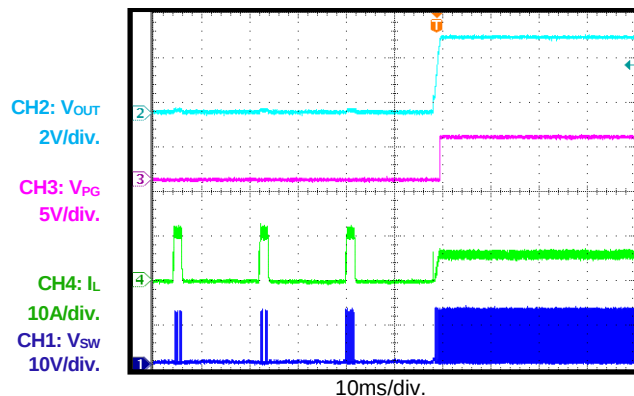
SCP Recovery

$I_{OUT} = 0A$, FCCM

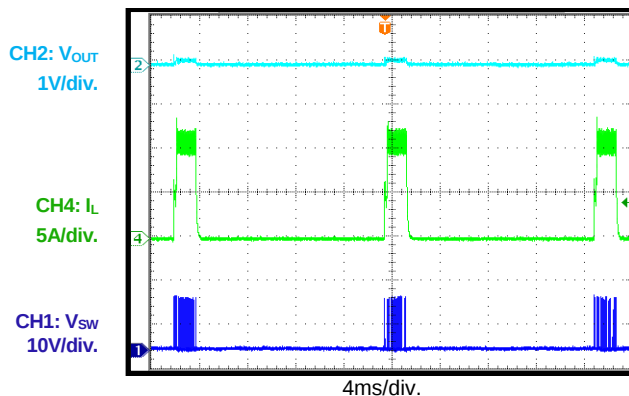


SCP Recovery

$I_{OUT} = 6A$

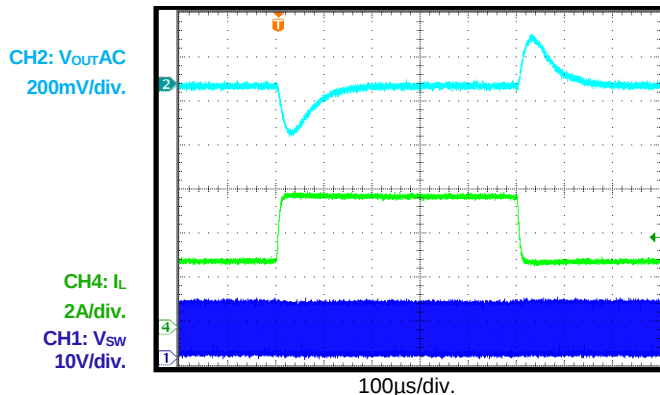


SCP Steady State



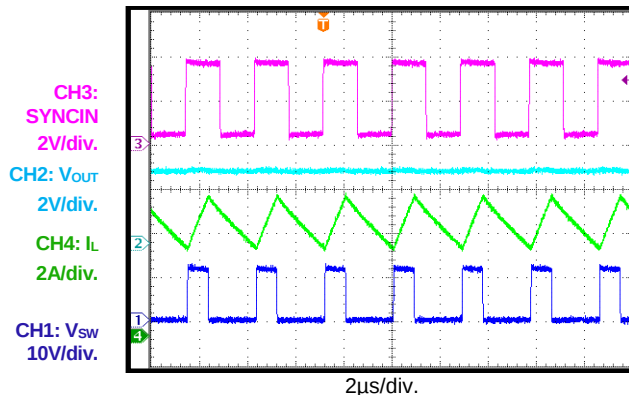
Load Transient

$I_{OUT} = 3A$ to $6A$



SYNC Operation

$I_{OUT} = 6A$, SYNC frequency = 350kHz

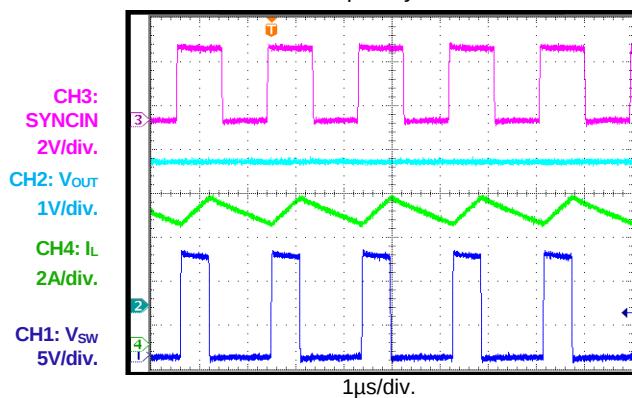


EVB TEST RESULTS (continued)

Performance curves and waveforms are tested on the evaluation board. $V_{IN} = 12V$, $V_{OUT} = 3.3V$, $L = 4.7\mu H$, $f_{SW} = 470kHz$, AAM, $T_A = 25^\circ C$, unless otherwise noted.

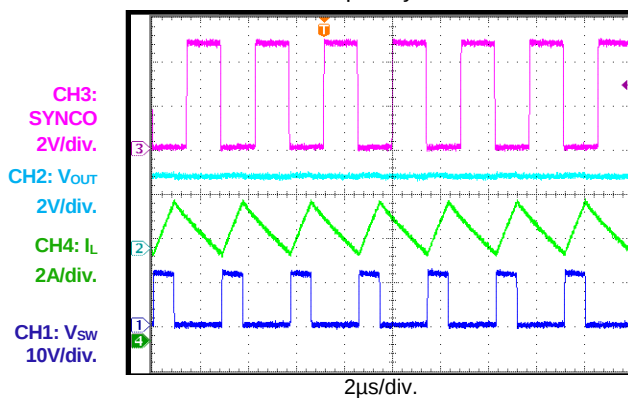
SYNC Operation

$I_{OUT} = 6A$, SYNC frequency = 530kHz



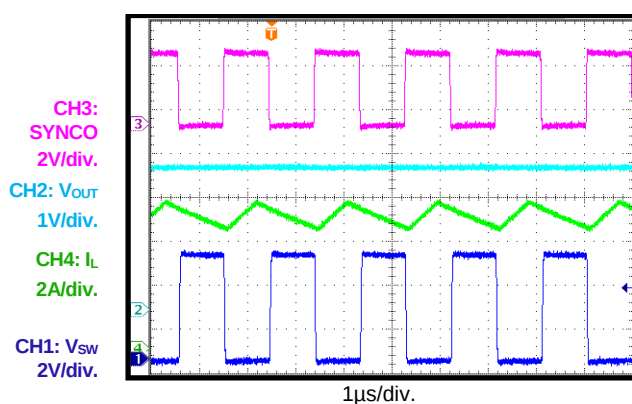
SYNC Operation

$I_{OUT} = 6A$, SYNC frequency = 350kHz



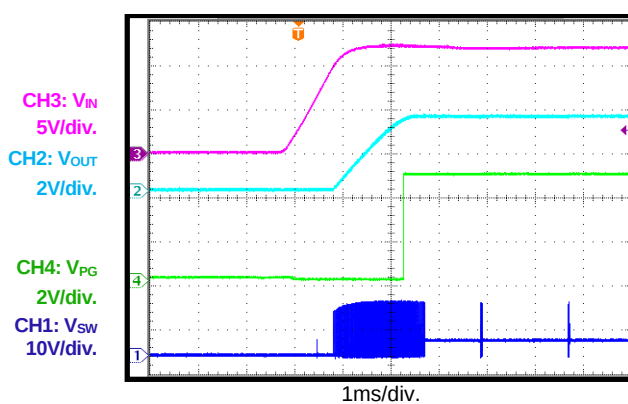
SYNC Operation

$I_{OUT} = 6A$, SYNC frequency = 530kHz



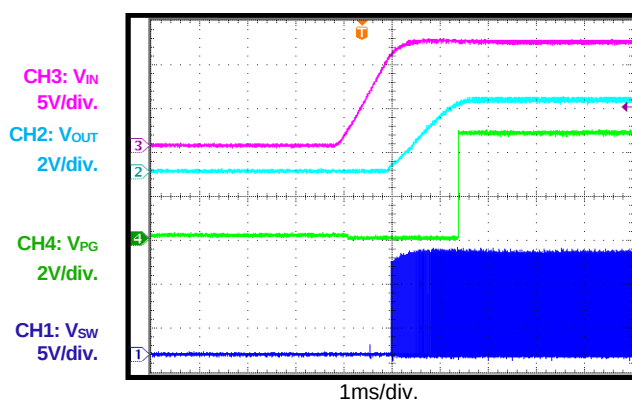
PG Start-Up through VIN

$I_{OUT} = 0A$



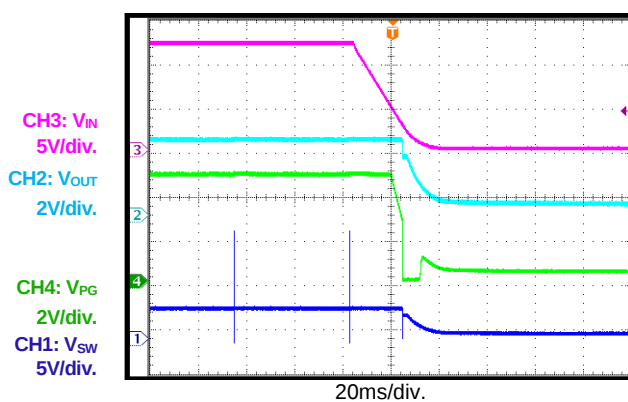
PG Start-Up through VIN

$I_{OUT} = 6A$



PG Shutdown through VIN

$I_{OUT} = 0A$



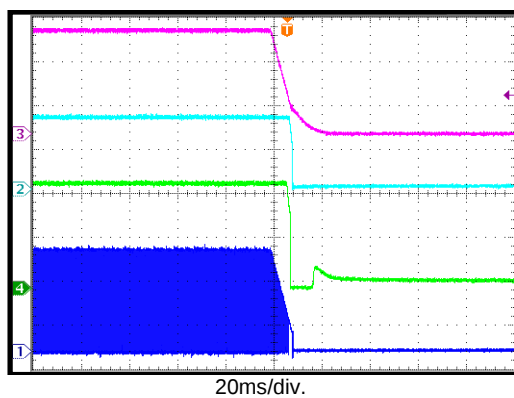
EVB TEST RESULTS (continued)

Performance curves and waveforms are tested on the evaluation board. $V_{IN} = 12V$, $V_{OUT} = 3.3V$, $L = 4.7\mu H$, $f_{SW} = 470kHz$, AAM, $T_A = 25^\circ C$, unless otherwise noted.

PG Shutdown through VIN

 $I_{OUT} = 6A$

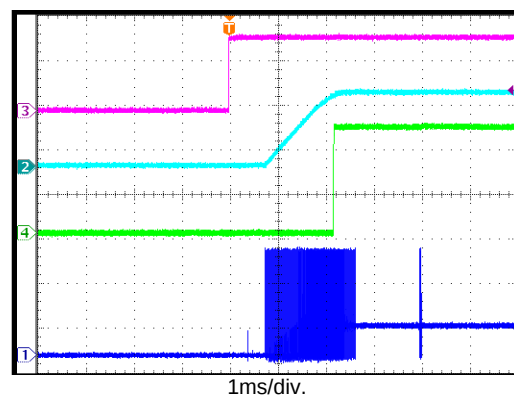
CH3: V_{IN}
5V/div.
CH2: V_{OUT}
2V/div.
CH4: V_{PG}
2V/div.
CH1: V_{SW}
5V/div.



PG Start-Up through EN

 $I_{OUT} = 0A$

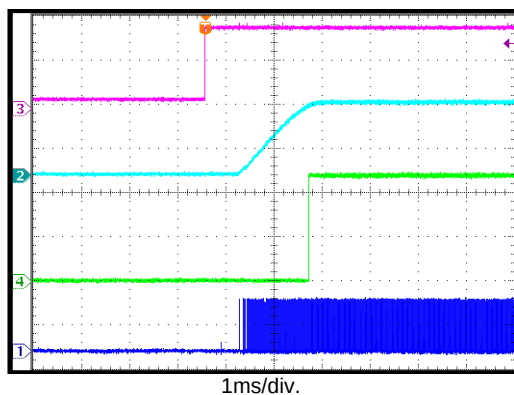
CH3: V_{EN}
2V/div.
CH2: V_{OUT}
2V/div.
CH4: V_{PG}
2V/div.
CH1: V_{SW}
5V/div.



PG Start-Up through EN

 $I_{OUT} = 6A$

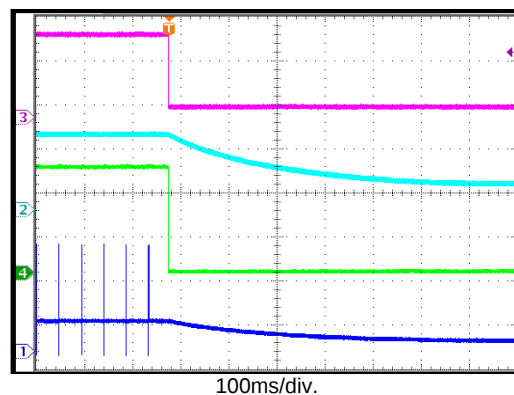
CH3: V_{EN}
2V/div.
CH2: V_{OUT}
2V/div.
CH4: V_{PG}
2V/div.
CH1: V_{SW}
10V/div.



PG Shutdown through EN

 $I_{OUT} = 0A$

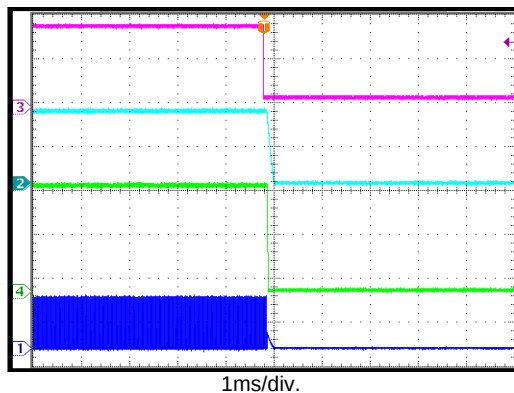
CH3: V_{EN}
2V/div.
CH2: V_{OUT}
2V/div.
CH4: V_{PG}
2V/div.
CH1: V_{SW}
5V/div.



PG Shutdown through EN

 $I_{OUT} = 6A$

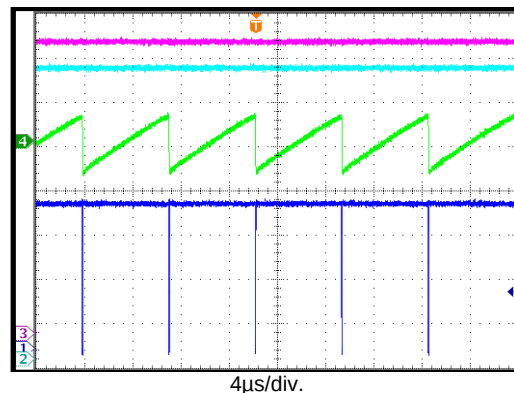
CH3: V_{EN}
2V/div.
CH2: V_{OUT}
2V/div.
CH4: V_{PG}
2V/div.
CH1: V_{SW}
10V/div.



Low-Dropout Mode

 $V_{IN} = 3.3V$, V_{OUT} set to 3.3V, $I_{OUT} = 0A$

CH3: V_{IN}
500mV/div.
CH2: V_{OUT}
500mV/div.
CH4: I_L
50mA/div.
CH1: V_{SW}
1V/div.

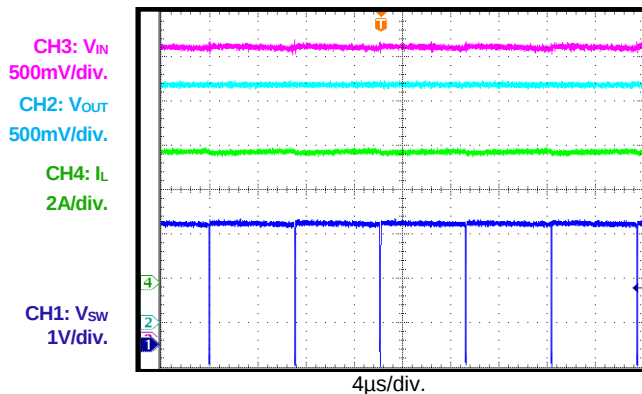


EVB TEST RESULTS (continued)

Performance curves and waveforms are tested on the evaluation board. $V_{IN} = 12V$, $V_{OUT} = 3.3V$, $L = 4.7\mu H$, $f_{SW} = 470kHz$, AAM, $T_A = 25^\circ C$, unless otherwise noted.

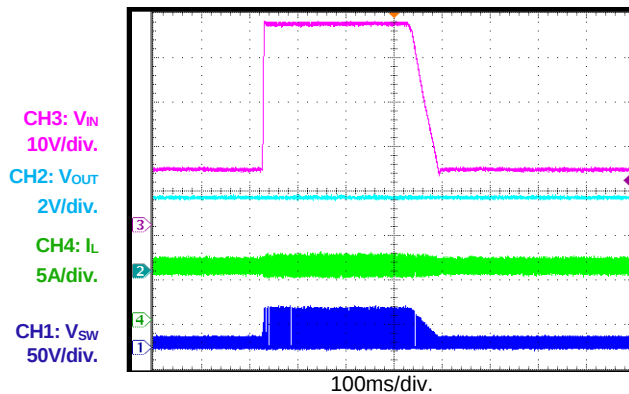
Dropout Operation

$V_{IN} = 3.3V$, V_{OUT} set to 3.3V, $I_{OUT} = 6A$



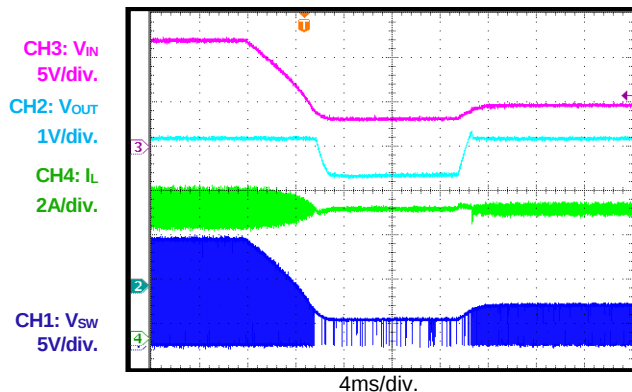
Load Dump

$V_{IN} = 12V$ to 36V, $I_{OUT} = 6A$



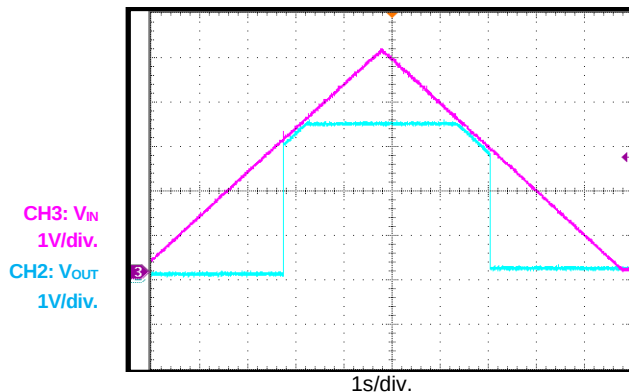
Cold Crank

$V_{IN} = 12V$ to 3.3V to 5V, $I_{OUT} = 6A$



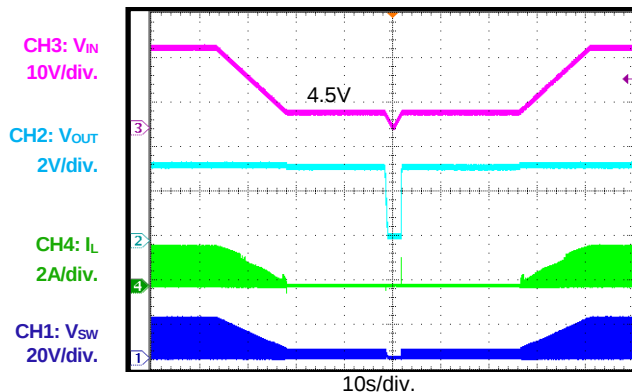
VIN Ramp Up and Down

$I_{OUT} = 0.1A$



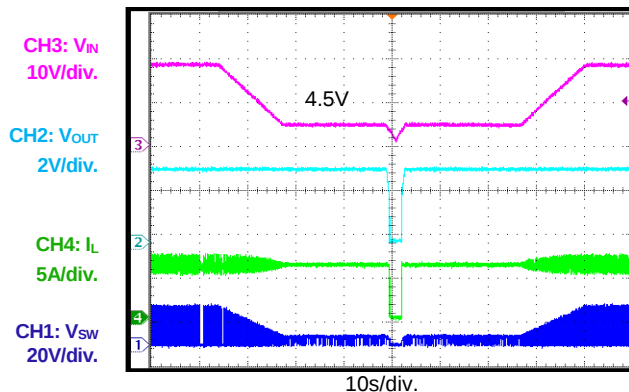
VIN Ramp Down and Up

$I_{OUT} = 1mA$



VIN Ramp Down and Up

$I_{OUT} = 6A$



PCB LAYOUT

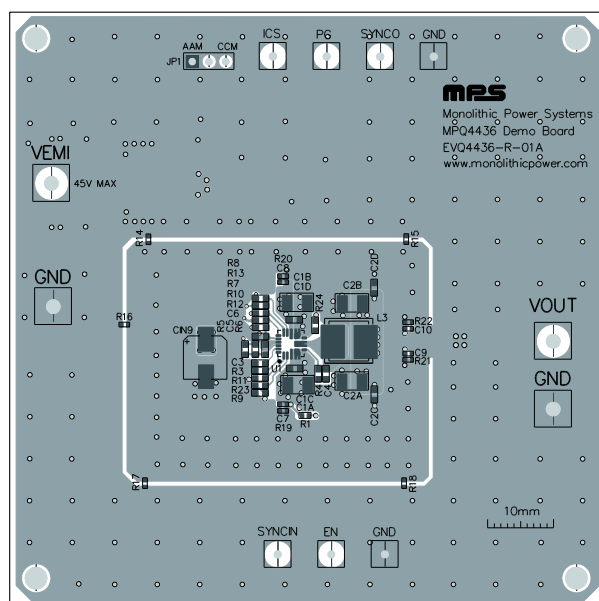


Figure 2: Top Silk Layer and Top Layer

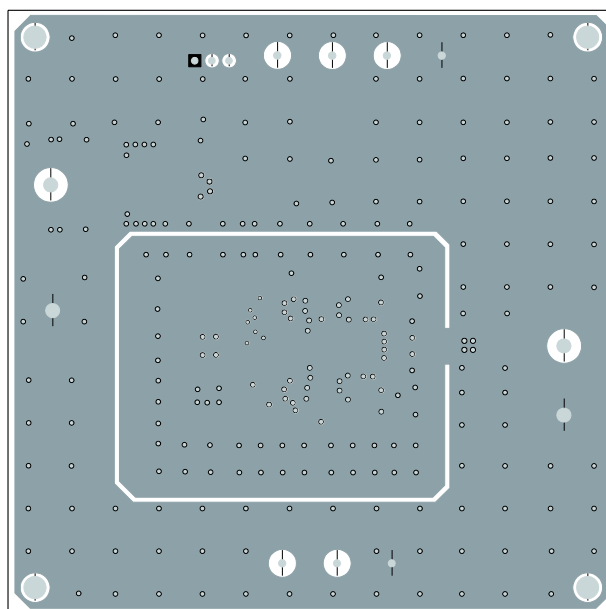


Figure 3: Inner Layer 1

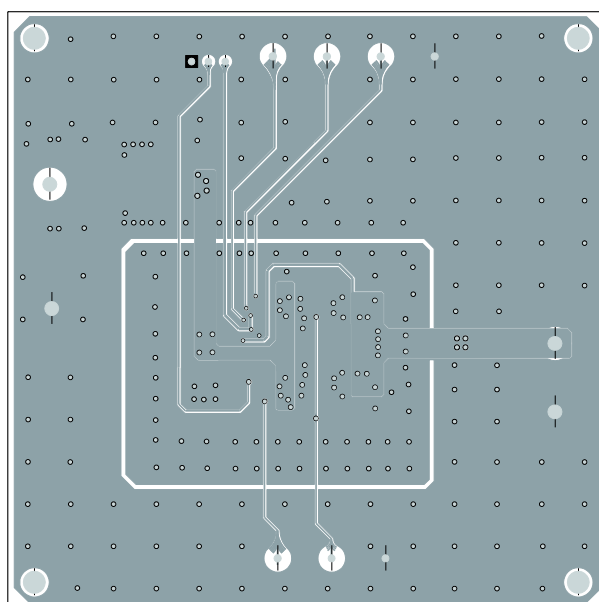


Figure 4: Inner Layer 2

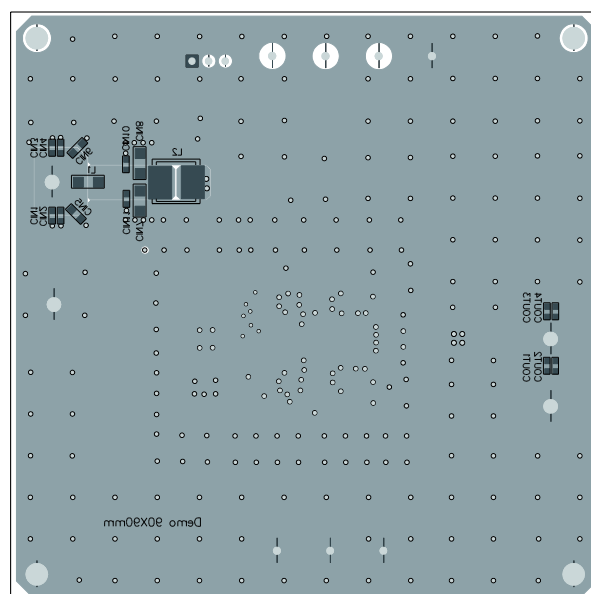


Figure 5: Bottom Silk Layer and Bottom Layer

Revision History

Revision #	Revision Date	Description	Pages Updated
1.0	8/31/2020	Initial Release	-

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